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EDITORIAL

Piezoelectricity of bone and electrical callus

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The year 2012 is the 60th anniversary of the discoveries of the piezoelectricity of bone and electrical callus, which were reported by Dr. Iwao Yasuda of our department for the first time in 1953, only 8 years after the end of World War II. The historians of the Japanese Orthopaedic Association have designated these accomplishments as "a great and proud Japanese achievement for orthopedics". Amazingly, Dr. Yasuda carried out these studies while facilities and human resources were extremely lacking. His frontier spirit must have encouraged young researchers to overcome difficulties and develop innovative ideas. I believe that his outstanding creativity had been partly brought about by the fact that he was studying in Kyoto.

Kyoto, which boasts 17 UNESCO World Heritage Sites, remained the Japanese capital for over 1,000 years beginning in AD 794. In this traditional city, original Japanese culture matured through the addition of the unique and inventive ideas of Asian traditions from the continent. It was also in this city that Toyo Yamawaki dissected a cadaver for the first time in Japan in 1754. This was 17 years prior to the publication of *Kaitai Shinsho*, a famous book about human anatomy translated from the Dutch by Genpaku Sugita. Even after the Japanese capital was moved to Tokyo in the Meiji Era, the creative spirit of the city of Kyoto remained active. The excavation of the Lake Biwa Canal, the first large-scale enterprise by a Japanese engineer, provided a stable supply of water for the citizens, mass transport, and Japan's first commercial hydroelectric power plant. The streetcar business began in this city using the electricity produced by the plant. Ten years before the start of this project, one of Japan's leading companies, the Shimadzu Corporation, was founded in Kyoto. Now the company provides medical systems, analytical and measuring instruments, and industrial and aircraft equipment, among other products. In 2002, Dr. Koichi Tanaka, who was working for the company, was awarded the Nobel Prize in Chemistry. More than 60 years ago, Shimadzu offered Dr. Yasuda an invaluable wire-strain gauge amplifier system, which was the key equipment in his experiments. Dr. Tanaka says that his discovery was the result of a monumental blunder. It is interesting that the discovery of the piezoelectricity of bone was also due to a mistake. Kyoto's unique traits of being originative and rich in tradition might be somewhat responsible for these achievements.

Electrical callus was discovered through research conducted following a study by Dr. Richard Maatz. He had proved that callus formation could be caused by tension (Maatz R. Die Reaktion des Knochens auf Federdruck. Arch Arth Unfall Chir. 1951;44:529–39). It is a mystery as to what led Dr. Yasuda to this German treatise. He was greatly encouraged by the work of Dr. Gerhard Küntscher that verified the "formation of callus without fracture". This phenomenon is also mentioned in a paper by Maatz, where he stated that "callus formation could be induced by mechanical, thermal, or chemical irritation".

Dr. Yasuda thought that mechanical stress would produce static energy in the bone. Then he inferred that electricity, the most controllable energy, might form callus. In addition, considering the relationship between the piezoelectricity of bone and electrical callus, he predicted that the piezoelectricity produced by deformation of collagen fibers stimulates osteocytes and causes cell proliferation.

Today, electrical and electromagnetic field stimulation are in medical use worldwide and enable patients with

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nonunion or delayed union to quickly return to normal life. Low-intensity pulsed ultrasound can also be categorized as physical stimulation. Not restricted to fracture healing, Yasuda's discovery laid the foundation of physical regulation in biology and medicine, such as callus formation in limb lengthening by applying electrical or ultrasound stimulation, determining bone union by measuring bone resistance values, and measurement of the biomagnetic fields of cells and tissue using superconducting quantum interference devices (SQUIDs). These varieties of application make us aware of his eminent ingenuity.

Now living in an information-oriented society, we must have the ability to detect and pick up the essential requisites for research activities. Our faculties have something in common with wit in that they can make a success out of failure. As well as having a knowledge of traditional studies, it may be more important to inherit the traditional spirit of being a groundbreaker.

I hope the continuous accumulation of creativity based on tradition will bring about a great leap toward the future of orthopedics.